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MAN 151-9510

T1500A OPERATOR MANUAL

T1500A FAULT LOCATOR OPERATOR MANUAL

WARRANTY

For a period of one year from its date of purchase new and undamaged from Polar Instruments Ltd, POLAR INSTRUMENTS LTD or its authorized distributors will, without charge, repair or replace at its option, this product if found to be defective in materials or workmanship, and if returned to POLAR INSTRUMENTS LTD or its authorized distributors transport prepaid. This warranty is expressly conditioned upon the product having been used only in normal usage and service in accordance with instructions of POLAR INSTRUMENTS LTD and not having been altered in any way or subject to misuse, negligence or damage, and not having been repaired or attempted to be repaired by any other than POLAR INSTRUMENTS LTD or its authorized distributors. EXCEPT FOR THE FOREGOING EXPRESS WARRANTY OF REPAIR OR REPLACEMENT POLAR INSTRUMENTS LTD MAKES NO WARRANTY OF ANY KIND, INCLUDING BUT NOT LIMITED TO, ANY EXPRESS OR IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE, AND POLAR INSTRUMENTS LTD SHALL NOT BE LIABLE FOR ANY DAMAGES, WHETHER DIRECT OR NOT OR OTHERWISE, BEYOND REPAIR OR REPLACING THIS PRODUCT.

DECLARATIONS

ELECTROMAGNETIC COMPATIBILITY

European Community Directive Conformance Statement

This product is in conformity with the protection requirements of EC Council Directive 89/336/EEC on the approximation of the laws of the Member States relating to electromagnetic compatibility.

A declaration of conformity with the requirements of the Directive has been signed by

POLAR INSTRUMENTS (UK) LTD
11 College Place
London Road
Southampton
England
SO1 2FE

This product satisfies EN50081-1:92 and EN 50082-1:92

SAFETY

WARNING

The LIVE and NEUTRAL lines on this unit are BOTH fused.

This unit contains no user-serviceable parts. When the unit is connected to its supply, the opening of covers or removal of panels is likely to expose dangerous voltages. To maintain operator safety, do not operate the unit unless the enclosure is complete and securely assembled.

GROUNDING

This unit must be earthed (grounded); do not operate the instrument with the safety earth disconnected. Ensure the instrument is connected to an outlet with an effective protective conductor terminal (earth). Do not negate this protective action by using an extension cord without a protective conductor.

Note: This instrument is fitted with 3-wire grounding type plug designed to fit only into a grounding type power outlet. If a special local plug must be fitted to the power cord ensure this operation is performed by a skilled electronics technician and that the protective ground connection is maintained. The plug that is cut off from the power cord must be safely disposed of.

Power cord color codes are as follows:

Europe

brown	live
blue	neutral
green/yellow	earth (ground)

United States

black	live
white	neutral
green	ground

POWER SUPPLY

Check that the indicated line voltage setting corresponds with the local mains power supply. See the rear panel for line voltage settings.

To change the line voltage settings refer the instrument to a skilled electronics technician. Instructions for changing the line voltage settings are contained in the T1500A Service Manual published by Polar Instruments.

T1500A OPERATION

This manual contains instructions and warnings which must be observed by the user to ensure safe operation. Operating this instrument in ways other than detailed in this manual may impair the protection provided by the instrument and may result in the instrument becoming unsafe. Retain these instructions for later use.

The T1500A is designed for use indoors in an electrical workshop environment at a stable work station comprising a bench or similar work surface.

Use only the accessories (e.g. test probes and clips) provided by Polar Instruments.

The T1500A must be maintained and repaired by a skilled electronics technician in accordance with the manufacturer's instructions.

If it is likely that the protection has been impaired the instrument must be made inoperative, secured against unintended operation and referred to qualified service personnel. Protection may be impaired if, for example, the instrument:

- Shows signs of physical damage
- Fails to operate normally when the operating instructions are followed
- Has been stored for prolonged periods under unfavourable conditions
- Has been subjected to excessive transport stresses
- Has been exposed to rain or water or been subject to liquid spills

CAUTION

Electrical Isolation

Always disconnect the board under test from the local mains supply (including ground) before using this instrument.

SPECIFICATIONS

ASA Test Ranges	Open Circuit Voltage	Short Circuit Current
Junction	1V	500µA
Logic	10V	5mA
Low	10V	150mA
Med	20V	1mA
High	40V	1mA
Hi-Cap (1Hz fixed)	10V	150mA
Low-Cap (2kHz fixed)	10V	20µA
ASA Test Frequencies		
Low	95Hz	
Medium	500Hz	
High	2kHz	
Display	Internal CRT	

Power Requirements

230V ± 10%, 115V ± 10% or 100V ± 10% at 50/60Hz, 40VA.

Physical characteristics (excluding accessories)

Dimensions	300 mm (11.8 in.) wide 110 mm (4.4 in.) high 260 mm (10.3 in.) deep
Weight	1.5 kg (3.3 lb.)

ENVIRONMENTAL OPERATING CONDITIONS

The instrument is designed for indoor use only under the following environmental conditions:

Altitude	Up to 2000m
Temperature	+5°C to +40°C ambient
Relative humidity	RH 80% maximum at 31°C — derate linearly to 50% at 40°C
Mains borne transients	As defined by Installation Category II (Overvoltage Category II) in IEC664
Pollution Degree	2 (IEC664)

ACCESSORIES

Standard Accessories

Probe set	MMP159
Test clip set	ACC110 (Red)
	ACC111 (Black)
Operator manual	MAN151

SYMBOLS

⚠ CAUTION — To prevent damage to this product and to ensure its safe use observe the specifications given in this manual when connecting to terminals marked with this symbol.

⏚ COM — This terminal is internally connected to earth (ground).

GUIDE TO THE MANUAL

INTRODUCTION	An overview of the Polar T1500A fault locator and its applications.
GENERAL DESCRIPTION	A description of the principles of operation and front and rear panels.
INSTALLATION AND SET UP	Connecting the T1500A to a power supply.
ASA DEVICE TESTING	Information about the different ways in which the ASA facilities of the T1500A can be used and how to test devices.
ASA SEMICONDUCTOR TESTING	Describes methods of testing signal diodes, zener diodes, LEDs and transistors in circuit.
SIMPLE MAINTENANCE	Details of maintenance and cleaning procedures.

CONTENTS

SECTION 1 – INTRODUCTION

THE T1500A FAULT LOCATOR

1-1 Introduction to the T1500A

The T1500A Fault Locator provides a fast and efficient means of testing components, either in isolation or in circuit.

All testing is done with power disconnected from the circuit, so there is no risk to the user and components under test cannot be damaged.

Two channels, A and B, enable the characteristics of a reference and a faulty component or circuit to be compared. Faults in complex circuits can thus be diagnosed without a high degree of technical skill or detailed knowledge of the circuit functions — this facility will be found particularly useful when documentation is not available.

1-2 Areas of application

The T1500A is an ideal instrument for a wide range of applications:

- Field Service – fault finding.
- Manufacturing – goods inwards testing and troubleshooting.
- Repair – rapid diagnostics.
- Education – examination of device characteristics.

1-3 Analog Signature Analysis

The T1500A Fault Locator tests components by applying a current-limited alternating (AC) drive voltage across the component and monitoring the resultant current flow to display *impedance signatures*. Signatures for different types of components have distinctly different shapes that can be easily distinguished.

The inclusion of two channels in the T1500A allows the user to compare the behaviour of two devices simultaneously.

SECTION 2 – GENERAL DESCRIPTION

PRINCIPLES OF OPERATION

2-1 T1500A controls, connectors and probes

The T1500A front panel

The front panel comprises:

Display Intensity — use to adjust display brightness

Trace Rotation — use to control trace orientation.

ASA range and frequency switches — use the voltage range and frequency switches to select appropriate drive voltages and frequencies during signature analysis.

Channel A and B probes — probe across devices (between Channel A and COM or Channel B and COM) to observe device signatures.

COM (common return) connector — connect the COM test clip to the ground of the board (or boards) under test.

Channel A position controls — use the Channel A position controls to move the channel A trace vertically and horizontally with respect to the Channel B trace.

The T1500A rear panel

The IEC power connector and power ON/OFF switch are mounted on the rear of the instrument.

2-2 Producing signatures

The T1500A applies an alternating voltage to a component or circuit and displays the resulting current versus voltage display on a CRT screen.

The voltage applied across the component is displayed horizontally, the current through the component is displayed vertically, so the resulting V/I graph represents the resistance, or impedance, of the component. This is defined as the *Impedance Signature* of the device.

The T1500A generates voltages of both polarities, i.e. applies both positive and negative voltages to a component, causing current to flow in both directions. The result is a four quadrant graph (see Figure 2-1).

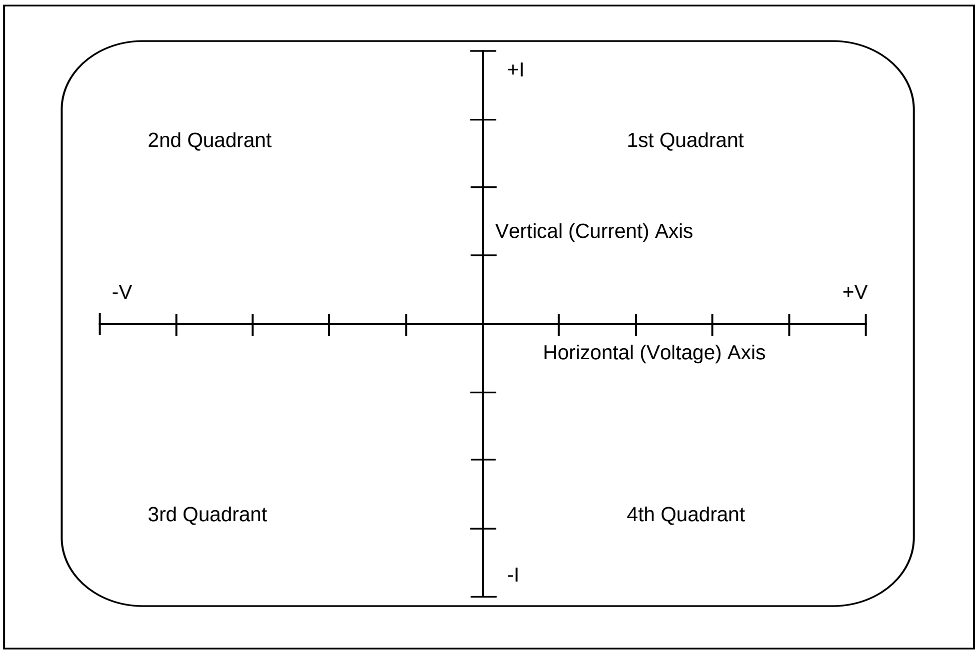


Figure 2-1 The T1500A CRT Display

2-3 Four-quadrant signatures

Impedance signatures are graphs of current against voltage, plotted on a scale which has its origin at the centre of the CRT display screen.

As the voltage applied to the component is driven positive and negative, positive voltages and currents are displayed in the upper right quadrant on the CRT, negative voltages and currents are displayed in the lower left quadrant.

The graticule marked on the CRT face is graduated so approximate current and voltage measurements can be made.

It is usually not necessary, however, to calculate actual current values in a component to verify its correct operation. When fault finding on an electrical circuit, the technician is frequently looking for components that have failed completely. Often, a brief glance at the signature of a suspect device will be sufficient to show whether it is good or defective.

2-4 The T1500A equivalent circuit

The T1500A can be represented by a voltage source, V_S, in series with an internal (or source) impedance, Z_S, and the component under test by a simple impedance, Z_L (Figure 2-2).

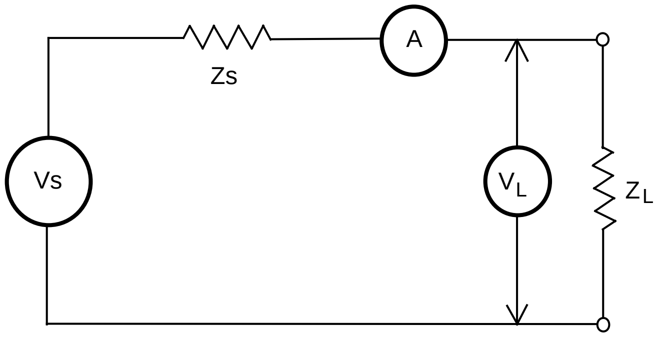


Figure 2-2 T1500A equivalent circuit

The T1500A contains circuits which measure the voltage across, and the current through, the component to be tested and output a display on the CRT.

The voltage, V_L, across the impedance, Z_L, will depend on the impedance of the component under test and controls the horizontal deflection of the display.

Current through the component under test will cause a voltage to be developed across the T1500A internal impedance, Z_S. This voltage controls the amount of vertical deflection on the display.

A high value impedance in the component under test (that is, high compared with the value of Z_S) will result in low circuit current (and therefore a low voltage across Z_S) with most of the T1500A source voltage, V_S, appearing across Z_L, producing a signature with a shallow slope.

A low value impedance will result in high circuit current and most of the source voltage developed across Z_S; the result is a steeply sloping signature.

Figure 2-3 shows the signatures of two resistors, measured on the same voltage range, superimposed. Component B has a greater resistance then component A.

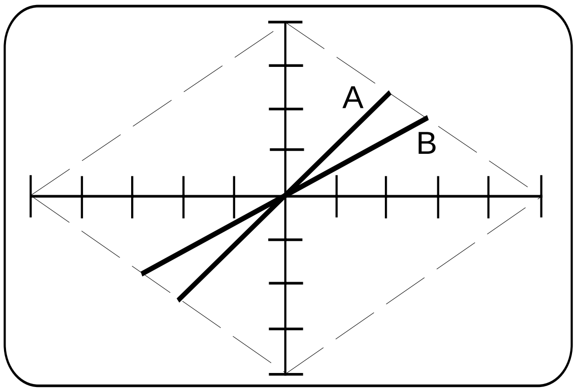


Figure 2-3 T1500A display showing two impedance signatures

SECTION 3 – INSTALLATION AND SET-UP

PREPARATION FOR USE

3-1 Unpacking

The instrument is shipped in a sturdy transit pack. Open the pack carefully and remove the instrument and its accessories.

If the instrument is damaged in any way contact the local distributor or supplier.

Retain the pack for possible future use.

The T1500A pack should contain:

T1500A
Power cord
Pair of probes
Pair of test clips
Operator manual

Note: If the instrument has been shipped or stored in a cold environment, allow the instrument to reach the temperature of its new location before applying power.

3-2 Connecting the T1500A to a power supply

Refer to the voltage label on the rear panel of the instrument and make sure that the marked rating is suitable for the local mains power supply.

If the rating on the label is not suitable for the local power supply refer the instrument to a skilled electronics technician. Instructions for changing the line voltage settings are contained in the T1500A Service Manual.

Note: If a special local plug must be fitted to the power cord ensure this operation is performed by a skilled electronics technician and that the protective ground connection is maintained. The plug that is cut off from the power cord must be safely disposed of.

Power cord color codes are as follows:

Europe

brown	live
blue	neutral
green/yellow	earth (ground)

United States

black	live
white	neutral
green	ground

3-3 Setting up the T1500A

1. Connect the power cord to the T1500A and to the power supply and switch on (the power switch is located at the rear of the instrument). The screen should display the Channel A and B outputs (two horizontal traces) about the screen centre.

   Caution: *The CRT phosphor could be burnt if the intensity is set too high and the same display is left on the screen for several hours.*

   Rotate the A POSITION horizontal and vertical controls and ensure that the Channel A trace moves correctly vertically and horizontally with respect to the Channel B trace. Adjust the X and Y position controls to centre the traces about the screen centre.

2. If the CRT trace is not perfectly horizontal, adjust the Trace Rotation control until the trace is parallel to the X axis. If the instrument is moved to a new location readjustment of the Trace Rotation control may be necessary.

3. Select the LOGIC RANGE and LOW FREQUENCY.

3-4 Connecting the test cables

Single Channel Applications

With the Red probe connected to the Channel A (or Channel B) socket, and the Black probe to the COM socket connect the probes across the device. When checking a signature at a node in a circuit it will often be appropriate to connect the COM socket to a convenient ground point using either a probe or test clip.

Dual Channel (Comparison) Applications

Connect the Red probe to the Channel A socket, the Black probe to the Channel B socket, and a test clip to the COM socket. Connect the COM test clip to the ground of the board under test.

If two boards are being compared, both grounds must be connected to the instrument's COM sockets.

SECTION 4 – ASA DEVICE TESTING

TESTING COMPONENTS

Using the Analog Signature Analysis method, safe, low power drive voltages are applied to components to produce "impedance signatures" on the oscilloscope screen. Impedance signatures are graphs of current against voltage, plotted on a scale which has its origin at the centre of the screen. This may be carried out on devices in or out of circuit. Positive voltages and currents are displayed in the upper right quadrant on the display. Negative voltages and currents are displayed in the lower left quadrant (see Figure 4-1 Display X and Y Axis).

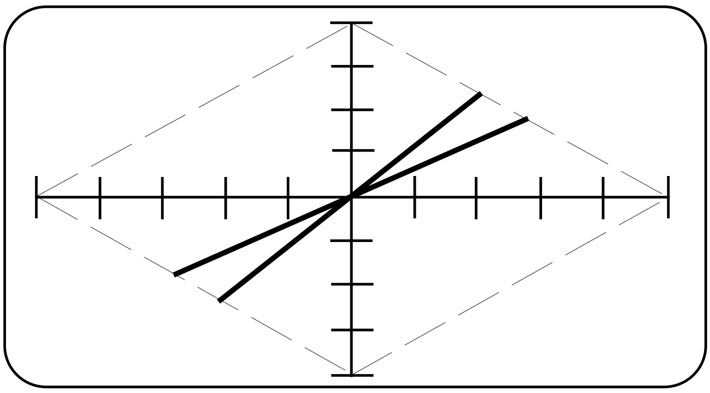


Figure 4-1 Display X and Y Axis

The graticule marks on the CRT face can be used for actual current and voltage measurements. Table 4-1 shows the scales for each voltage range.

Range	Peak Voltage	Horizontal	Peak Current	Vertical
Junction	1V	0.2V/div	500µA	0.125mA/div
Logic	10V	2V/div	5mA	1.25mA/div
Low	10V	2V/div	150mA	37.5mA/div
Med	20V	4V/div	1mA	0.25mA/div
High	50V	10V/div	1mA	0.25mA/div
Hi-Cap	10V	2V/div	150mA	37.5mA/div
Lo-Cap	10V	2V/div	20µA	5µA/div.

Table 4-1 Drive Ranges

All signatures are contained within the diamond shaped area formed by the “load lines” joining the ends of the marked axes.

4-1 ASA techniques

The most effective way to use ASA is by comparison with a known good or reference board.

The primary object of the comparison technique is to look for *differences* between signatures. Using this technique will almost always prove the easiest and speediest method of fault finding. There is often no need to analyse the shape of a signature in detail.

To begin with, it is best to look at the signatures of nodes that connect to external circuits (e.g. connectors), as any damage to the board is quite often the result of some external influence.

Where reference boards are unavailable, it is important to try and obtain circuit diagrams in order to predict with reasonable accuracy the signature of the nodes under test. The user is again recommended to start by looking at the signatures on the board’s connectors.

It is worth checking whether there are multiple similar circuits on the board under test, (for example, a dual-channel modem or 4-channel audio amplifier).

These types of boards may have their individual channels compared just as if they were separate boards. In such cases, exercise caution, however, when differences do arise. Check that the separate channels are identical in the areas which show up different signatures—circuit differences may be intentional.

Troubleshooting without documentation

If diagrams and reference board are not available, predicting signatures is obviously more difficult, but it is still worth probing components like relays, known types of ICs and 3-terminal devices and looking for the appropriate signature shape.

Even with no access to a reference board or to circuit diagrams the operator should be suspicious of digital devices with signatures that are not diode-like, i.e. signatures with sloping lines. Note, however, that some input protection diodes have a series resistance which will produce a noticeable slope if tested with the LOW range.

Remember that on microprocessor buses, parallel ports, etc., the operator should expect to see similar signatures on all the lines. If one is noticeably different from the others treat this line with suspicion. However, if they *all* look a little strange, this is probably not a fault.

Typical faults

It is worth keeping in mind that faults are not confined to the "high technology" areas of the board. Most faults will be in the "low technology" sections, e.g. intermittent connections, "dry" solder joints, reversed diodes.

For instance, the following faults are equally likely:

an open circuit relay coil,
a broken trace on a printed circuit board,
a broken transistor lead.

Remember that most service faults will be catastrophic device failures. Many faults include broken connections of one sort or another (often resulting in open circuit signatures) or short circuits (e.g. solder "bridges") so look particularly for unexpected "straight line" signatures.

In general, when troubleshooting a complete circuit module such as a plug-in circuit card, examine signatures in the following order:

edge connectors
other connectors
large ICs
small ICs
other components

4-2 Testing resistors

The signature produced by a pure resistance is an inclined straight line whose slope (gradient) is dependent on the value of resistance.

Testing resistors is performed by connecting the probes across the device and observing the slope of the displayed signature.

Select the voltage range which allows signatures and signature differences to be most easily observed—a high value of resistance will only pass a small current if a low test voltage is applied.

The resulting signature may not be easily distinguishable from the open circuit horizontal trace. By selecting a higher voltage range a larger current flows and a more recognisable sloping signature is displayed.

Table 4-2 gives the ranges against approximate resistor values for which signatures can be distinguished from a short circuit (vertical trace) or an open circuit (horizontal trace).

Range	Resistor Value (Ohms)
Junction	1K to 50K
Logic	300R to 6K
Low	16.5R to 300R
Med	5K to 60K
High	12K to 150K

Table 4-2 Resistance Ranges

Figures 4-2, 4-3 and 4-4 show typical signatures for three resistor values.

Figure 4-2

2K Resistor
Logic **Range**
Low **Frequency.**

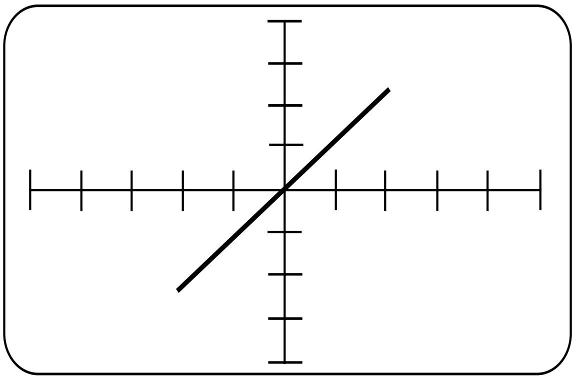


Figure 4-3

10K Resistor
Med Range
Low Frequency

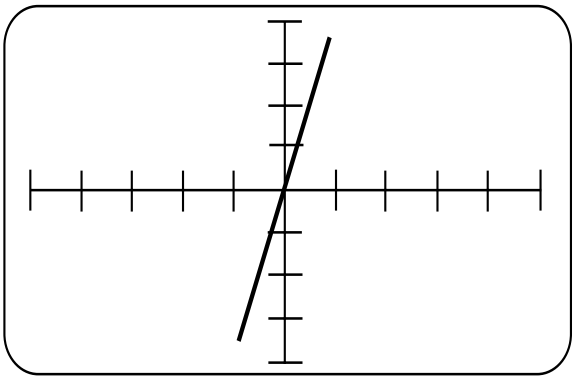
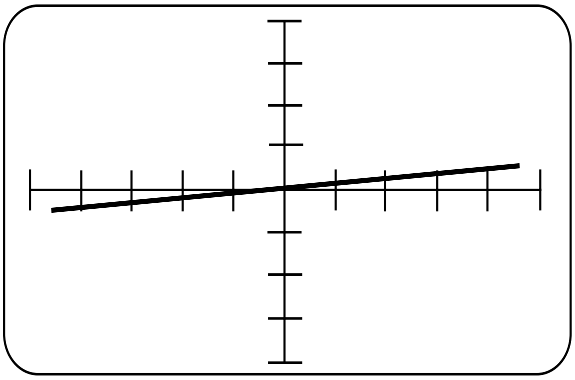


Figure 4-4

270K Resistor
Med Range
Low Frequency



4-3 Testing capacitors

Due to their energy storage characteristics, reactive components produce a phase shift between voltage and current flow. This is displayed as a circular or elliptical signature. See Figure 4-5.

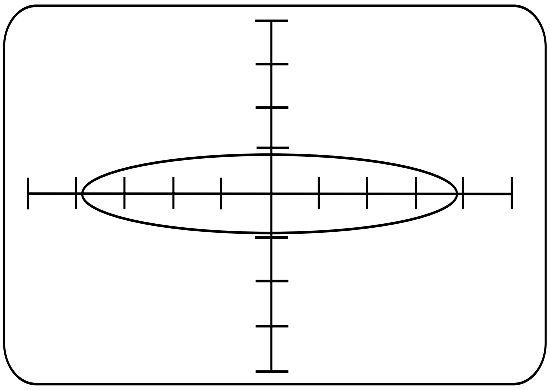


Figure 4-5 Signature of a good capacitor

Note that for a pure reactance the major and minor axes of the ellipse align with the vertical and horizontal graticule lines. The vertical deflection of the ellipse represents the current through the capacitor, and will therefore increase with larger values of capacitance (as the reactance decreases inversely with capacitance).

Table 4-3 shows the range of capacitors covered by each combination of drive voltage and frequency.

			Frequency	
Range		**Low**	**Med**	**High**
LO-CAP				35pF – 800pF
Logic		300nF – 6µF	56nF – 1µF	15nF – 300nF
Low		6µF – 100µF	1µF – 20µF	300nF – 5µF
Med		30nF – 300nF	5nF – 68nF	1.5nF – 15nF
High		10nF – 150nF	2nF – 30nF	500pF – 7nF
HI-CAP	500µF – 12000µF			

Table 4-3 Capacitor Range

Choosing capacitor testing ranges

Capacitor signature shapes can vary between a virtually horizontal line for low values of capacitance through the range of ellipse shapes (including a circle) to a line that is almost vertical for high capacitance values.

Using the higher frequency ranges will cause greater vertical deflection and make subtle differences in signatures easier to detect.

For very small or large capacitors use the fixed frequency LO-CAP or HI-CAP ranges.

Figures 4-6 and 4-7 show typical signatures for capacitors on the Low Range and Low Frequency settings.

Figure 4-6

22µF capacitor
Low Range
Low Frequency

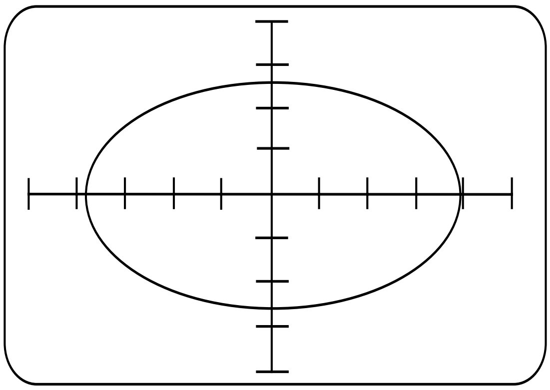
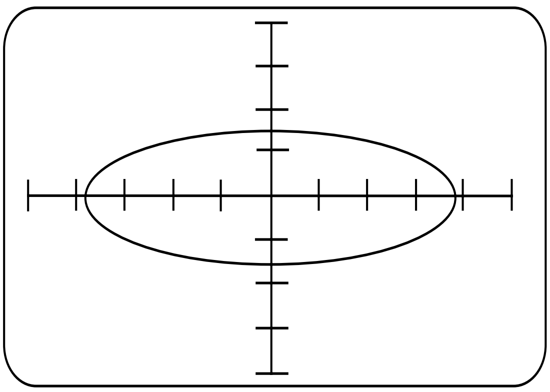


Figure 4-7

10µF capacitor
Low Range
Low Frequency



Leakage current in capacitors.

In practice, because of leakage current, the capacitor will behave as if it were a perfect capacitor with a resistor connected between its plates. Leakage currents represent a power loss in capacitors and, if large enough, lead to problems in a circuit.

The amount of leakage current that is acceptable will depend on the circuit, but will normally be very much smaller than capacitive current. Leakage current is greatest in electrolytic capacitors because of their construction and impurities in the insulating material.

Total current is thus made up of capacitive current and leakage current, and a real capacitor can be considered as consisting of a pure capacitance in parallel with a high value resistor.

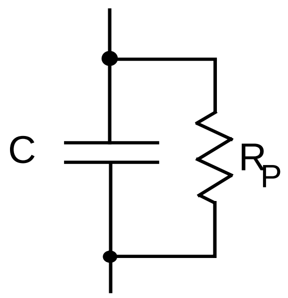


Figure 4-8 Equivalent circuit of a capacitor

Figure 4-8 illustrates the equivalent circuit of a "real" capacitor, comprising capacitance C and parallel resistance R_P.

In a good capacitor the value of R_P will be high, so leakage current will be negligibly small (R_P is effectively open circuit).

The T1500A causes current to flow through both the capacitance and the parallel resistance. The resulting signature will be the sum of the resistive and capacitive components – Figure 4-9.

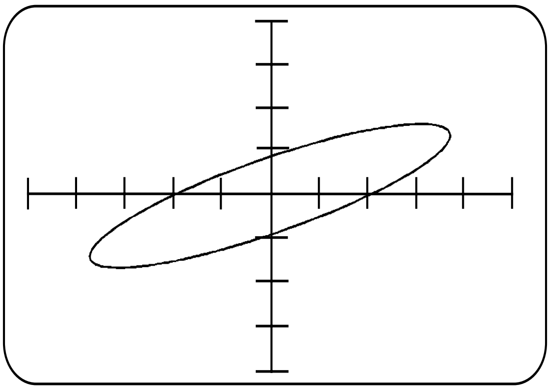


Figure 4-9 Signature of a "leaky" capacitor

Note the tilt in the ellipse. This is due to resistive current in the capacitor and indicates a faulty capacitor.

In general, if the leakage current in a capacitor is significant compared with the capacitive current, the elliptical signature will be tilted.

By choosing a different test frequency to vary the impedance, the effect of resistance can be exaggerated or minimised as required.

Capacitors in circuit

In many applications capacitors are connected in parallel, with small capacitors connected across large electrolytics. In such cases it will probably be necessary to disconnect one of the capacitors from the circuit and test the capacitors separately.

Note that large capacitors for smoothing in power supplies are frequently connected directly across a transformer secondary winding and also across a diode bridge — the resulting signature can be difficult to predict so use comparison testing if a reference circuit is available, or isolate the components from circuit.

Some types of capacitor are prone to short circuits between the plates, particularly polystyrene capacitors which may have been subjected to excessive heat during assembly or repair. The insulation in these components can easily melt at normal soldering temperatures, bringing the plates into physical contact.

4-4 Inductors

Inductive reactance is dependent on the inductance value of the coil and the frequency of the applied voltage, not the "ohmic" resistance of the coil.

The magnitude of the current flowing depends on:

1. The inductance of the coil
2. The frequency of the applied voltage

So reactance will rise and current will fall with rising frequency or inductance.

The result of inductive action is that, as in capacitors, the voltage and current do not increase and decrease simultaneously.

This is reflected in their signatures.

Signatures of inductors

Inductors exhibit time delay between voltage and current in a manner similar to capacitors, and similarly display elliptical signatures, but there are significant differences.

Inductors are not simple inductances but are a combination of inductance and resistance. Because they are coils of wire, they are able to pass current directly so at low frequencies appear as very low value resistances. At high frequencies, reactance increases compared with the resistance, so the signature looks more inductive than resistive, taking on a more elliptical shape.

However, the signature can be difficult to predict (for example, inductors with iron cores can "saturate") and signatures can show considerable distortion. For this reason, the best technique for testing inductors is the comparison technique.

		Frequency	
Range	**Low**	**Med**	**High**
Logic	500mH – 11H	100mH – 2H	25mH – 500mH
Low	30mH – 500mH	6mH – 100mH	1.5mH – 25mH
Med	10H – 110H	2H – 10H	500mH – 5H
High	20H – 30H	4H – 50H	1H – 12H

Table 4-4 Inductor Range

Figure 4-10 shows the signature of a ferrite transformer primary winding with the test voltage range set **Low** and test frequency set **High**. This demonstrates the effect of a significant value of resistance causing the inductive ellipse to be tilted.
Figure 4-11 shows a similar (defective) transformer with a shorted turn.

Figure 4-10

Ferrite transformer
Primary winding
Low Range
High Frequency

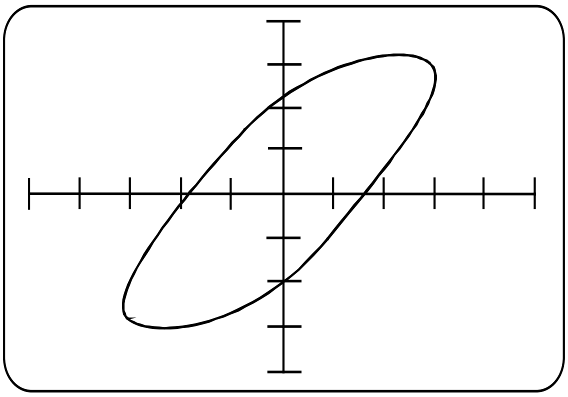
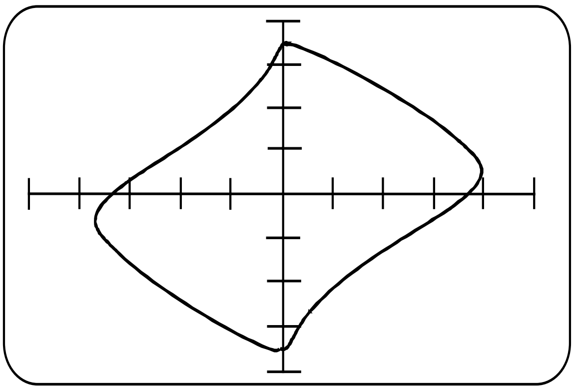


Figure 4-11

Ferrite Transformer
Primary winding
Low Range
High Frequency
Shorted turn



SECTION 5 – ASA SEMICONDUCTOR TESTING

USING ASA TO TEST SEMICONDUCTORS

5-1 Diodes, LEDs and Zeners

When forward biased, a diode exhibits a low resistance and a voltage drop of approximately 0.6V. This produces a signature that is an almost vertical trace close to the Y axis (see Figure 5-1).

When reverse biased, the high resistance characteristics of the diode approaches that of an open circuit, producing a horizontal trace close to the X axis. A light emitting diode (LED) shows a similar signature to a conventional diode, except that the forward voltage drop is approximately 1.5V.

A Zener diode exhibits the same signature as a conventional diode for voltages below the Zener voltage. When the reverse bias exceeds the Zener voltage, a low resistance signature is displayed. Figure 5-2 shows the signature of an 8.2V Zener diode.

When testing Zener diodes the graduations on the display X axis can be used to measure the Zener voltage.

Suitable voltage ranges are:

Signal diodes	**Junction**
Power diodes	**Low**
LEDs	**Logic**
Zener diodes	**Med** up to 20V

NOTE: The signatures are inverted if the test probe and COM connections are reversed.

Figure 5-1

Signal diode
Logic Range
Low Frequency

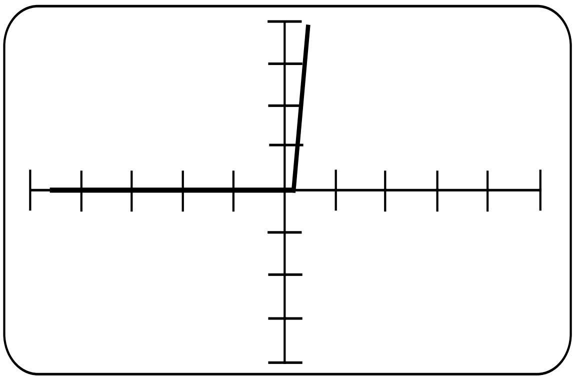
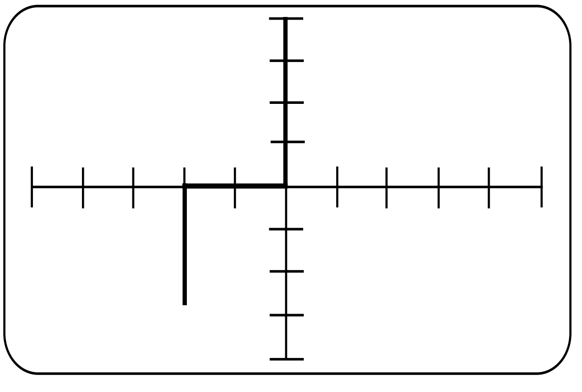


Figure 5-2

8.2V Zener diode
Med Range
Low Frequency



5-2 Testing transistors in circuit

In many fault finding situations it may not be possible or practicable to remove a device from circuit. The T1500A can be used to test transistors as described in this section.

A transistor contains two semiconductor junctions connected "back-to-back" (one between base and collector, the other between base and emitter).

Figures 5-3 – 5-5 show typical signatures for an NPN transistor (in which the collector and emitter are N-type material and the base P-type) if the probes are connected across the associated device terminals.

The base-emitter signature (Figure 5-3) is similar to that for a Zener diode. *High-frequency small signal transistors should not be operated in this mode for long periods. Prolonged reverse-breakdown of the base-emitter junction may permanently affect the characteristics of the device.*

The base-collector (Figure 5-4) signature is similar to that of a conventional diode.

The collector-emitter signature (Figure 5-5) is similar to that of a diode in series with a Zener diode. When the drive voltage is positive (right quadrant) the collector-base is reverse biased and the base-emitter forward biased. The reverse biased collector-emitter prevents current flow, producing an open-circuit signature (a horizontal line). When the drive voltage is negative (left quadrant), the collector-base is forward biased and the base-emitter reverse biased. The base-emitter exhibits Zener breakdown as described above, producing a Zener "tail" signature. Note the warning above about operation of the transistor with the base-emitter reverse biased.

The signatures for a PNP transistor will be mirror images of those for an NPN transistor.

Identifying Transistor Terminals

The terminals of an unknown transistor may be identified as follows:

Select **Logic** Range, **Low** Frequency.

Connect the COM clip to one lead of the transistor and probe the other two leads in turn, looking for a match with the signatures shown in Figures 5-3 – 5-5. If the signatures are mirror images of the figures, the transistor is a PNP device.

Figure 5-3

NPN Transistor
base-emitter
Med Range
Low Frequency

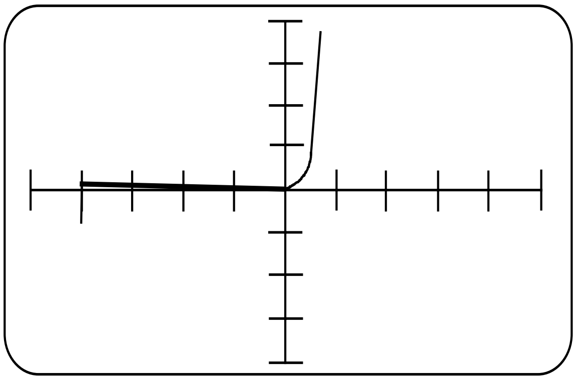


Figure 5-4

NPN Transistor
base-collector
Med Range
Low Frequency

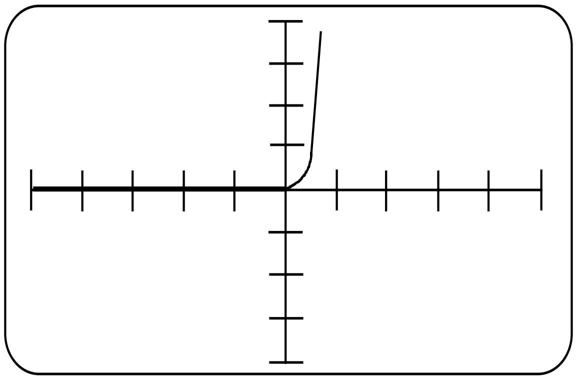
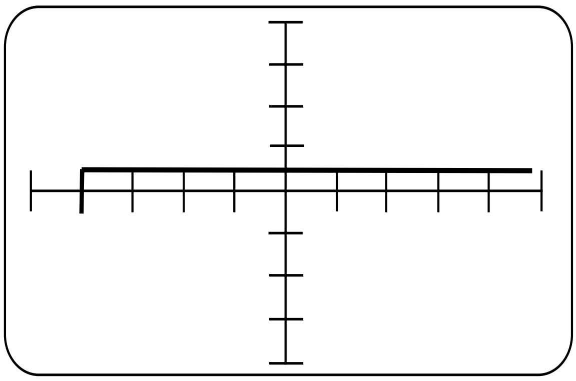


Figure 5-5

NPN Transistor
emitter-collector
Med Range
Low Frequency



5-3 Field Effect Transistors (FETs)

Junction FETs (JFETs)

The junction field effect transistor (JFET) consists of a bar of semiconductor material (the “channel”) and a region doped with material of the opposite semiconductor type to the channel (the “gate”). The gate forms a diode junction with each end of the channel (the “source” and “drain”) and these may be tested as conventional diodes.

Metal-Oxide Semiconductor FETs (MOSFETs)

*CAUTION: Observe static precautions whenever handling MOSFETs. Use **Logic** range for testing (or **Low** for power MOSFETs). Do not use the **Med** range.*

MOSFETs are field effect transistors in which the gate is insulated from the channel. The gate-drain and gate-source tests will usually produce an open-circuit signature, although some MOSFETs have a protection diode between the gate and source. In these cases the gate-source signature will be that for a Zener diode.

5-4 Integrated Circuits

The **Logic** and **Junction** ranges and **Low** frequency are recommended for use when testing ICs. All integrated circuits can be tested by probing pairs of terminals. Most ICs tested in this way display signatures similar to diodes or Zener diodes.

Note: ICs manufactured using different technologies can have distinctly different signatures. This must be considered before diagnosing a device as faulty.

When testing an IC it is usually appropriate to connect COM to the ground pin of the IC. Alternatively COM can be connected to Vcc.

> In some circumstances unstable signatures can occur. Connecting **both** ground and Vcc pins to COM can overcome this effect.

Figures 5-8, 5-7 and 5-8 show signatures for a 74LS00 IC.

The signature in Figure 5-8 is dominated by the input protection diode with its anode connected to the COM probe via circuit ground. The signature in Figure 5-7 is more complex as several output components within the IC influence the trace. The signature in Figure 5-8 shows the effect of a network of components within the IC.

The corresponding signatures for an HC gate (74HC02) and 4000 series CMOS (4017) are shown in Figures 5-9 to 5-11 and Figures 5-12 to 5-14 respectively.

Figure 5-6

74LS00
Logic Range
Low Frequency
Input to ground

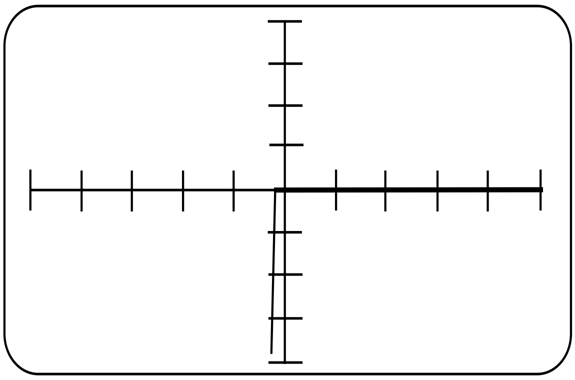


Figure 5-7

74LS00
Logic Range
Low Frequency
Output to ground

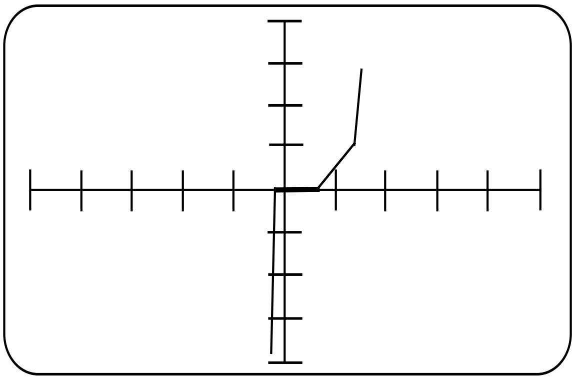


Figure 5-8

74LS00
Logic Range
Low Frequency
Vcc to ground

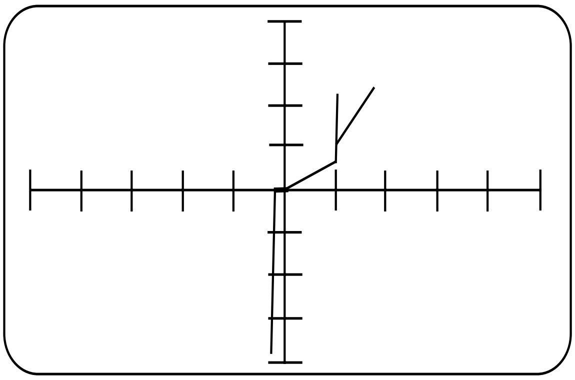


Figure 5-9

74HC02
Logic Range
Low Frequency
Input to ground

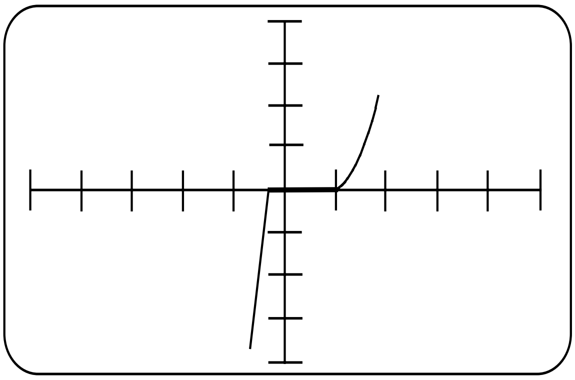


Figure 5-10

74HC02
Logic Range
Low Frequency
Output to ground

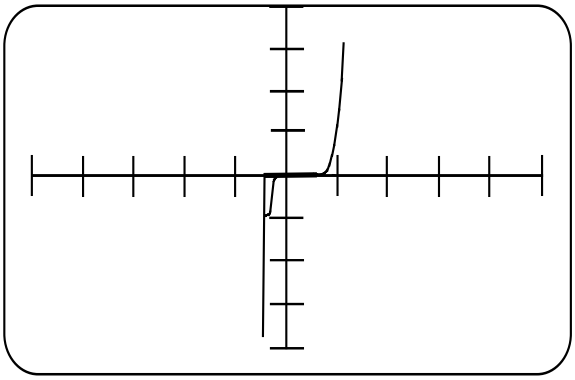


Figure 5-11

74HC02
Logic Range
Low Frequency
Vcc to ground

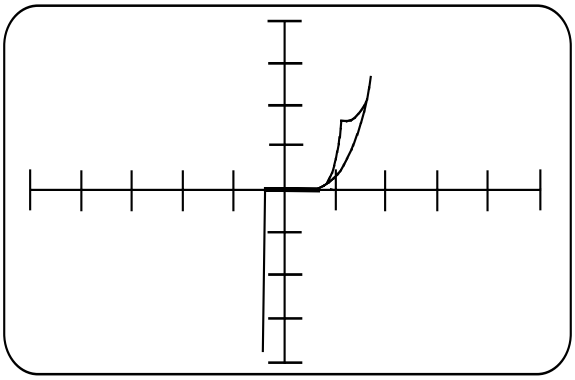


Figure 5-12

4017
Logic Range
Low Frequency
Input to ground

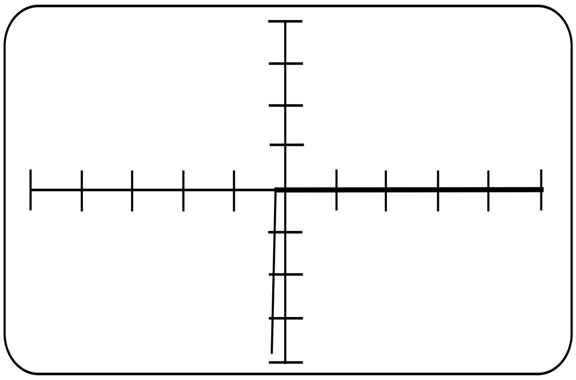


Figure 5-13

4017
Logic Range
Low Frequency
Output to ground

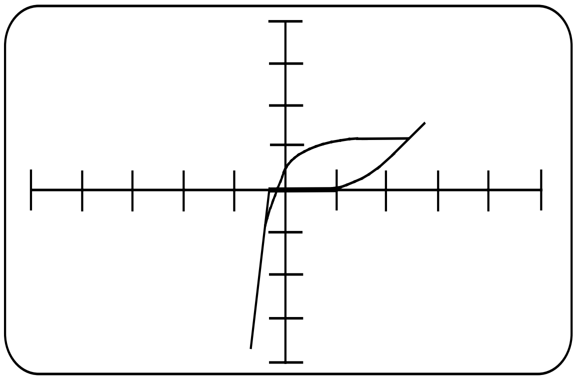
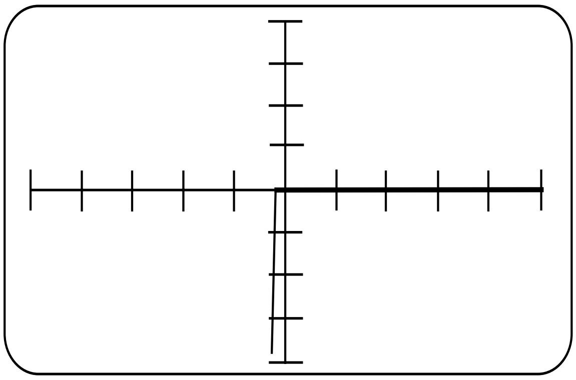


Figure 5-14

4017
Logic Range
Low Frequency
Vcc to ground



An example of a defect in an IC is shown in Figures 5-15 and 5-16. Figure 5-15 shows the signature between input and ground of a good IC type 7650 tested in circuit. Figure 5-16 shows the signature of a defective 7650 in the same circuit, where the input protection diode has become leaky.

Note that in Figures 5-9, 5-11, 5-13, 5-15 and 5-16 loops are evident due to capacitance within the ICs. Using **Med** or **High** frequency will exaggerate this effect. In general **Low** frequency should be used when testing ICs.

Figure 5-15

7650 in circuit
Logic Range
Low Frequency
Input to ground

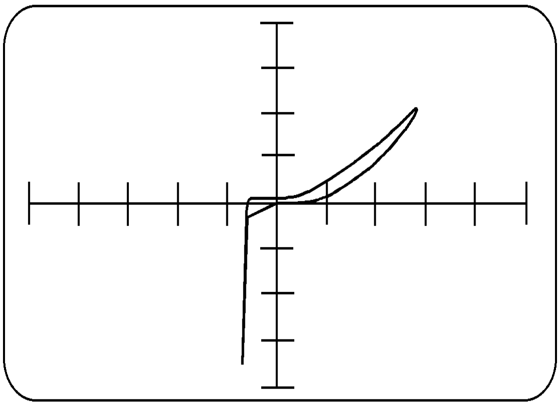
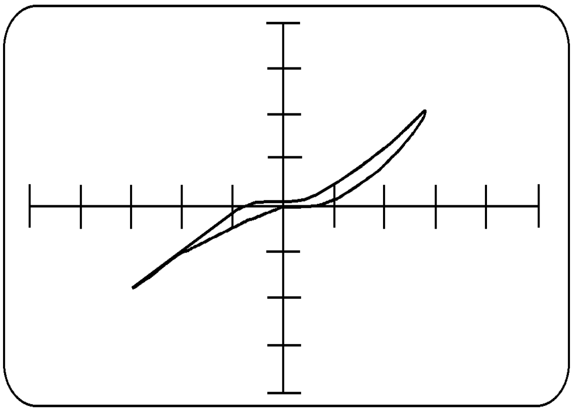


Figure 5-16

7650 in circuit
Logic Range
Low Frequency
Input to ground
Defective device



5-5 Testing Devices in Circuit

When testing a component in circuit, the signature is a composite of that device and other components in parallel. This is most often the case when diagnosing faults in service.

The characteristic signature at any probing point in a circuit is unique for that circuit. Using Channels A and B to display the signatures of a suspect circuit and that of a good circuit is the best way to identify a fault.

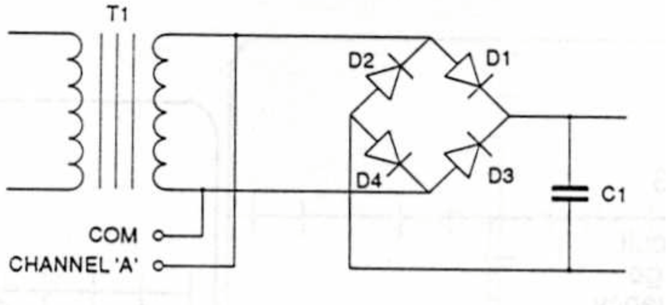
A faulty component may affect the signatures of several connected components. The operator can 'home-in' on a fault by probing at several points in the circuit.

Circuit Example

Figure 5-18 is the signature of the power supply circuit shown in Figure 5-17 when probed at the secondary winding of the transformer. The ranges used are **Low** voltage and **Low** frequency. The looping of the signature is caused primarily by the smoothing capacitor (C1). The slope of the axes of the ellipse arise from diode resistances in circuit. The "knees" at either end of the ellipse are caused by the diodes in the rectifier bridge.

Figure 5-17

Power Supply Circuit



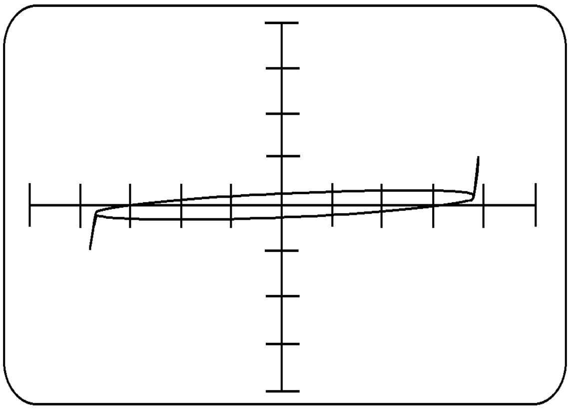


Figure 5-18

Signature at secondary winding good circuit

Figure 5-19 shows the effect on the signature in Figure 5-18 when one diode (D3) develops a short circuit.

During the positive half cycle of the drive voltage (right quadrant) the signature is effectively that of diode D1. The remaining components are short circuited by D3. During the negative half cycle (left quadrant) the signature is a composite of two current paths, one through the transformer secondary, the other through the short circuited D3, C1 and D2.

It is rarely necessary to analyse signatures in such detail. In this example the lack of symmetry clearly indicates the fault. Moving the probes to test each component in the circuit quickly leads to probing across the short circuited diode.

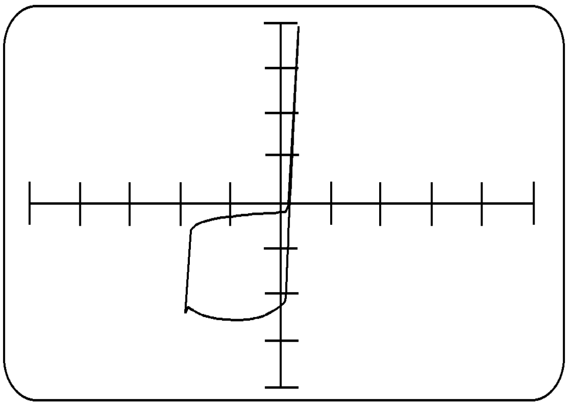


Figure 5-19

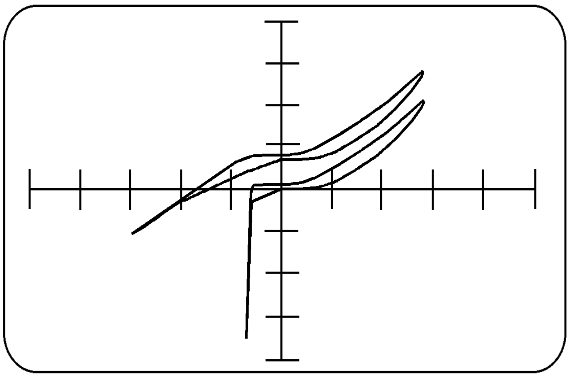
Signature at secondary winding D3 short circuit

Figure 5-20 shows the effect of superimposing two signatures to aid comparison diagnosis.

Note: When comparing the signatures of two circuits ensure that both circuits are connected to COM at the equivalent circuit points.

Figure 5-20

7650 in circuit
Input to ground
Channel 'A' (upper) – defective
Channel 'B' (lower) – good



5-6 Testing Bus-connected devices

When a number of devices are connected together on a common bus, the signatures on the bus lines may be compared to look for differences. Lines on the same bus will usually have similar signatures (e.g. all data lines will be similar to each other). If one line has a different signature from other lines on the same bus, this suggests that a device on that bus is faulty.

To isolate the fault to a specific device there are a number of methods:

1. If any devices are socketed, remove them one by one until the defective line's signature matches the other lines.

2. Each device will have one or more pins that are **not** connected to a bus, e.g. /CE (Chip Enable) or /OE (Output Enable). This provides a method for looking at the ICs individually. Instead of connecting the T1500A's COM input to Vcc or ground, connect it to the defective bus line. Probe each of the devices' /OE or /CE pins, looking for a device whose signature differs from other similar devices.

3. If neither of the above methods locate the fault, it may be necessary to unsolder devices until the fault is cleared.

Figure 5-21 shows the signature of a data bus line of a microprocessor in circuit.

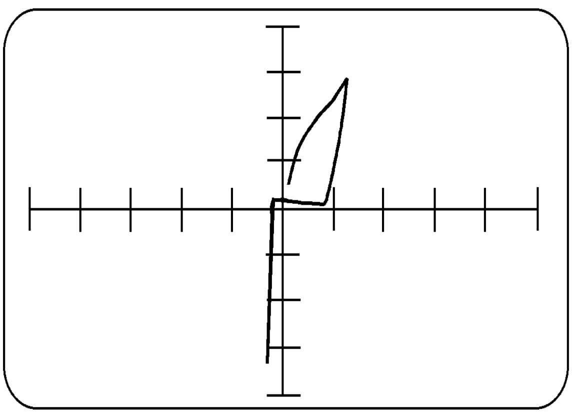


Figure 5-21

Microprocessor
data bus
in circuit

SECTION 6 – SIMPLE MAINTENANCE AND CLEANING

WARNING This instrument should only be serviced by a qualified electronics technician.

Refer all servicing to qualified service personnel. Polar Instruments publishes a T1500A Service Manual to assist the service technician.

Fault diagnosis

Symptom	Cause
Trace appears as a vertical (short-circuit) signature with channel unconnected.	The problem most likely to be encountered is a blown Channel Protection Fuse. Channels A and B are each protected by fast blow fuses. If the probes are connected to a powered board, or a large, charged capacitor, the fuses open to minimise damage to the T1500A. When a channel is unconnected, its normal signature is a horizontal line. If its protection fuse has blown, then a vertical (short-circuit) signature will be displayed. If a fuse needs to be replaced refer the T1500A to qualified service personnel.
Trace unstable	Check that the COM lead is connected. If testing ICs, connect the V_{CC} and ground pins together.

Cleaning

Clean the T1500A with a cloth lightly moistened with water with a small amount of mild detergent. Alternatively, a cloth lightly moistened with alcohol (ethanol or methylated spirit) or isopropyl alcohol (IPA) may be used.

Do not spray cleaners directly onto the instrument.

Technical Support

For technical support contact your local Polar Instruments distributor or Polar Instruments.